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Creative Thinking Skills in Chemistry Learning: A Systematic Literature Review

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Abstract: Creative thinking is one of the abilities needed in facing the 21st century era. Various problems in learning chemistry make students have to be creative thinkers to solve the problems they face. This study aims to determine creative thinking skills in chemistry learning. The method used is Systematic Literature Review (SLR) which adopts 5 stages from Denyer and Tranfield with the criteria of articles on creative thinking skills in learning chemistry indexed by Scopus, Sinta 1, and Sinta 2 from 2014 to 2023, full text and open source. There were 17 articles that fit these criteria. The results of the literature review show that most studies involve chemistry education students as prospective teachers who have an important role in developing students' creative thinking skills. In addition, most studies aim to investigate the effect of learning models on creative thinking skills. Project Based Learning (PjBL) model with a STEM approach is the most effective learning used to improve creative thinking skills with student learning outcomes of 83.00. Based on the results of the literature review, it was found that there is a positive relationship between learning outcomes and creative thinking skills. The better students' learning outcomes, the better their creative thinking skills.

Keywords: Chemistry learning; Creative Thinking Skill; Literature review

Introduction

Education in the 21st century requires young people to have a variety of certain skills and abilities in order to compete and face global challenges. The skills needed by each individual in the 21st century are critical thinking, collaboration, communication, and creativity (Chusni et al., 2020). A person does not have these skills from birth, but acquired through practice, learning, and experience (Redhana, 2019). The learning process in all educational institutions is required to implement student-centered learning so that learning can encourage 4C skills (Vong & Kaewurai, 2017).

The importance of creativity has emerged in all aspects of life to design things, create change, and overcome problems with the aim of improving quality of life (Lawless et al., 2018). Wiyarsi et al. (2018) revealed that creativity is useful for finding solutions or creating ideas and perspektif to overcome various problems in everyday life. Creative thinking skills can be seen from the ability of learners to solve complex problems, identify relationships that are not directly visible, and develop adequate conceptual models to explain phenomena (Lawless et al., 2018).

Wiyarsi et al. (2018) stated that in chemistry learning, student needs creativity in thinking whic is an essential skills because it is useful for observing everything such as chemical representations. The goal of learning chemistry is to improve students' understanding of chemical concepts and relate them to real-world situations. In chemistry, there are various phenomena, challenges, and processes related to chemical representations. Chemical representation is a determining factor that distinguishes chemistry from other fields of science (Apriwanda & Hanri, 2022). Therefore, creative thinking ability is considered a very important skill in chemistry learning.

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Currently, students' creative thinking skills in Indonesia have not reached optimal development and are still in the low category. PISA results in 2018 showed that Indonesian students' creative thinking skills ranked 74th out of 79 countries (Dewi & Mashami, 2019) with a score of 396 out of a maximum score of 500 (Lestari & Ilhami, 2022). PISA scores show evidence that the level of creative thinking of Indonesian students is low. The results of the PISA study are in line with previous studies which found that the level of creativity of students' thinking in chemistry learning is low (Ernawati et al., 2019a; Kusumawardani et al., 2015; Magdalena et al., 2014; Siregar et al., 2021; Zulkarnaen et al., 2022). The role of teachers contributes to the low level of creative thinking, as they have the potential to stimulate the development of each student's creative potential through the provision of facilities for the development of knowledge and skills related to creativity in the context of formal education (Apriwanda & Hanri, 2022).

A learning paradigm that can increase student interest, introduce chemistry, provide opportunities to solve real-world problems, and develop their skills is needed to overcome these problems. An effective way to develop students' creative thinking skills is to use a learning model that actively involves students in thinking. The chosen learning model must help students to learn and gain knowledge by finding it themselves (Dewi & Mashami, 2019; Sumarni & Kadarwati, 2020). Creative thinking skills can be developed through contextual and student-centered learning (Suradika et al., 2023). For this reason, there is a need for systematic research related to creative thinking skills in chemistry learning offered from several existing studies to see variations and possible developments, so that it can be used as a reference for others.

Method

This research uses the Systematic Literature Review (SLR) method. The SLR method is the process of identifying, evaluating and analyzing all information in a reference or literature to discuss the topic to be studied (Xiao & Watson, 2019). Systematic reviews focus on the use of topics that appear in articles. This research is prioritized on the objectives, subjects, chemistry concepts, approaches, models, strategies, and learning methods used. The data sources in this study came from various journal articles within the last 10 years regarding creative thinking skills in chemistry learning. This SLR research procedure adopted from Denyer and Tranfield (2009) which was also reported to have been used by other authors such as Han et al. (2020); Husamah et al. (2022); Murti & Hernani (2023). The five steps of SLR in this study are presented in Figure 1.

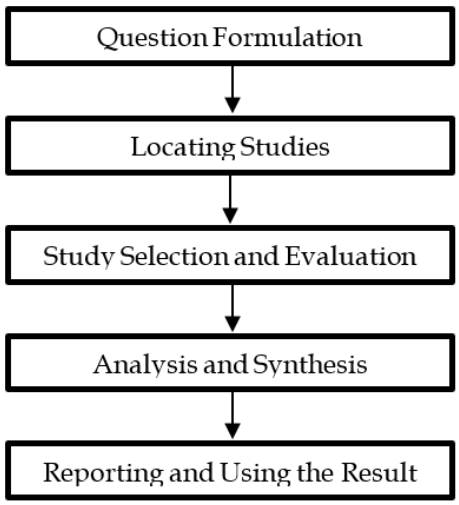

Figure 1. The steps of a systematic literature review

Question Formulation

This first step is to decide on the scope to develop a clear research focus. This research proposes several questions that are based on the chosen topic. These questions serve as parameters in this research.

Table 1. Question formulation in this research

Number	Question Formulation
1.	What is the aim of researching creative thinking skills in chemistry learning?
2.	Who are the subjects involved in the research?
3.	What learning model is used to improve creative thinking skills in chemistry learning?

Locating Studies

The second step aims to search the search database related to review questions. The keyword used in the search was "Creative Thinking Skills in Chemistry Learning". The Process of searching for data sources through the Google Scholar and Scopus Database. The search utilized these terms to explore relevant articles published in national and international journals indexed by Sinta and Scopus. Journals must be published in 2014-2023**.** The search process uses the help of the Publish or Perish (PoP) application.

Study Selection and Evaluation

The articles used in this study were based on the following inclusion criteria: 1) articles on creative thinking skills in chemistry learning, 2) Scopus, Sinta 1, and Sinta 2 indexed articles, 3) Publication from 2014 to 2023, 4) fulltext and open access articles. Searching articles with the keyword Creative thinking skills in chemistry learning produced 63 related articles. Then the articles were selected based on consideration of the sustainability of the title, abstract, and inclusion criteria so that 17 articles were obtained that met the predetermined criteria. Table 2 shows the results of screening 17 articles.

Analysis and Synthesis

After selected articles, the next step was to synthesize the results from the relevant literatures. The data synthesis in this study is in the narration form.

Reporting and Using the Result

This step is the last step in the Systematic Literature Review. This step involves systematically presenting the results of the literature review in written format, following a pre-defined structure

Table 2. Screening Results of Article used in the Systematic Literature Review

Authors	Title of Journal	Name of Journal
Adah & Akomaye (2022)	Effect of Problem-Based Learning on Acquisition of Creative Thinking Skills Among Chemistry Students in Ogoja Education Zone, Cross River State, Nigeria	International Journal of Education and Evaluation (Q3)
Apriwanda & Hanri (2022).	Level of Creative Thinking Among Prospective Chemistry Teachers	Jurnal Pendidikan IPA Indonesia (Q3)
Dewi & Mashami (2019)	The Effect of Chemo-Entrepreneurship Oriented Inquiry Module on Improving Students' Creative Thinking Ability	Journal of Turkish Science Education (Q2)
Ernawati et al (2019a)	Identifying Creative Thinking Skills in Subject Matter Bio-Chemistry	International Journal of Evaluation and Research in Education (Q3)
Ernawati et al (2019b)	Development of Creative Thinking Skill Instruments for Chemistry Student Teachers in Indonesia	International Journal of Online and Biomedical Engineering (Q2)
Ernawati *et al* (2022)	How Scaffolding Integrated With Problem Based Learning Can Improve Creative Thinking in Chemistry?	European Journal of Educational Research (Q3)
Hasibuan *et al* (2022)	Application of Integrated Project-based and STEM based E-Learning Tools to Improve Students' Creative Thinking and Self Regulation Skills	Jurnal Penelitian Pendidikan IPA (S2)
Lestari *et al* (2020)	The Effect of The Flipped Classroom and Self Efficacy on A Guided Inquiry on Students' Creative Thinking Skills	Jurnal Pendidikan Kimia (S2)
Nuswowati *et al* (2017)	Implementation of Problem Based Learning with Green chemistry vision to improve creative thinking skill and students' creative action	Jurnal Pendidikan IPA Indonesia (Q3)
Perdana *et al* (2020a)	The Effectiveness of Inquiry Social Complexity to Improving Critical and Creative Thinking Skills of Senior High School Students	International Journal of Instruction (Q2)
Perdana *et al* (2020b)	Inquiry Social Complexity (ISC): Design Instructional to Empowerment Critical and Creative Thinking Skills in Chemistry	Periodico Tche Quimica (Q2)
Sari *et al* (2017)	Profile of Students' Creative Thinking Skills on Quantitative Project-Based Protein Testing Using Local Materials	Jurnal Pendidikan IPA Indonesia (Q3)
Sihaloho *et al* (2022)	Students' Creative Thinking Skills on Reaction Rate Topic Through Contextual Teaching and Learning Model	Jurnal Tadris Kimiya (S2)
Sumarni & Kadarwati (2020)	Ethno-STEM Project-Based Learning: Its Impact to Critical and Creative Thinking Skills	Jurnal Pendidikan IPA Indonesia (Q3)
Sumarni *et al* (2022)	STEM-PBL-Local Culture: Can It Improve Prospective Teachers' Problem Solving and Creative Thinking Skills?	Journal of Innovation in Educational and Cultural Research (S2)
Yerimadesi *et al* (2022)	Implementation of Guided Discovery Learning Model With SETS Approach Assisted by Chemistry E-Module to Improve Creative Thinking Skills of Students	Jurnal Penelitian Pendidikan IPA (S2)
Zatya *et al* (2022)	Implementation of Project Based Learning Through the STEMC Approach to Improve Students' Creative Thinking Skills	Jurnal Penelitian Pendidikan IPA (S2)

Result and Discussion

Results of Aim Theme

Based on the synthesis of 17 articles, it was found that research on creative thinking skills in chemistry learning was conducted with various objectives. The theme of research objectives on creative thinking skills in chemistry learning is divided into three broad lines. There is one article that aims to produce a creative thinking skills assessment instrument with various studies that examine the profile of students' creative thinking skills level. Most of the studies aimed to explore the effectiveness and influence of learning models on creative thinking skills. The researchers mostly want to examine how effective learning models are to improve students' creative thinking skills in chemistry learning.

Table 3. Result of Research Aim Theme in Creative Thinking Skill

Research Aim	Percentage (%)
Explore the effectiveness of learning models on students' creative thinking skill	76.4
Explore the profile of students' creative thinking skills in chemistry learning	17.7
Produce of creative thinking skill instrumen	5.9

Results of Subject Theme

Based on the 17 synthesized articles, it was found that most of the creative thinking skills research involved undergraduate students as prospective chemistry teachers. This fact shows that prospective teachers have an important role in developing students' creative thinking skills (Apriwanda & Hanri, 2022; Ernawati et al., 2019a), so prospective teachers must have the ability to provide this role so that creative thinking skills can increase. Prospective teachers will be directly involved in learning chemistry in schools, where they will form individuals who are creative, innovative and ready to face future challenges (Ernawati et al., 2019a; Adah & Akomaye, 2022; Nuswowati et al., 2017). The distribution of the Research Subject Theme is presented in Table 4.

Table 4. Result of Research Subject Theme

Research Subject	Percentage (%)
Undergraduate students of chemistry education	58.8
High School student	41.2

Result of Learning Models

The selection and application of learning models can affect creative thinking skills (Dewi & Mashami, 2019; Ernawati et al., 2022; Lestari et al., 2020; Perdana et al., 2020b; Sumarni & Kadarwati, 2020; Zatya et al., 2022). Based on the synthesis of 17 articles that have been conducted, there are several learning innovations that can improve creative thinking skills. Integrating learning models with certain approaches or strategies is one of the efforts that teachers can make in the learning process.

Problem-based learning (PBL) is most widely used to improve creative thinking skills. PBL is a learner-centered learning model that uses problems as the main focus. The goal is for learners to process information accurately and creatively, overcome and solve the problems given, and improve their learning abilities and learning achievements (Ernawati et al., 2022). Problems encourage students to share knowledge, associate alternative ideas, build arguments to support the established solution (Nuswowati et al., 2017). The application of PBL can improve students' skill to think creatively, because it involves group activities where each group member participates in the exchange of ideas and contribute their ideas to find solutions (Ernawati et al., 2022; Sumarni et al., 2022). Based on 5 articles that examine PBL, two of them are the integration of scaffolding strategies in PBL. Scaffolding is a strategy that provides assistance to students, especially at the beginning of learning and during the problem-solving process, with the intention of later reducing that assistance so that students can take responsibility for themselves when they feel competent (Ernawati et al., 2019b). Ernawati et al. (2022) revealed that scaffolding in PBL can help students to construct basic concepts and creative thinking skills in learning.

Table 5. Result of Learning Models

Model Type	Integrated Model	Persentage (%)
Problem Based Learning (PBL)	PBL (1) PBL-Scaffolding (2) PBL-green chemistry (1) PBL-STEM (1)	33.3
Project Based Learning (PjBL)	PjBL (1) PjBL-STEM (3)	26.7
Inquiry Based Learning	Guided Inquiry-Flipped Classroom (1) Inquiry-ChemoEntrepreneurship (1) Inquiry Social Complexity (ISC) (2)	26.7
Contextual Teaching-Learning Model	Contextual based learning (1)	6.7
Discovery Learning	Guided Discovery Learning-SETS (1)	6.7

In addition to the integration of scaffolding strategies, PBL can also be integrated with green chemistry to improve creative thinking skills. PBL integrated with green chemistry makes students able to identify real-world problems and find solutions by pouring their creative ideas in the context of the problems faced by using the principles of green chemistry. The application of PBL-green chemistry can facilitate the balance of hand on and mind on skills that affect the improvement of student learning outcomes as well as creative thinking skills and creative actions (Nuswowati et al., 2017). STEM integrated in the PBL model connects scientific concepts with indigenous knowledge of society, technology, engineering and mathematics. This learning is done by presenting problems that must be solved through literature study, questions and answers, group discussions, and investigations to find solutions. This activity series is proven to facilitate creative thinking process in problem solving (Sumarni et al., 2022).

Another alternative to develop students' creative thinking skills is through the application of the Project Based Learning (PjBL) model (Hasibuan et al., 2022; Sari

et al., 2017; Sumarni & Kadarwati, 2020; Zatya et al., 2022). PjBL is learning that involves students in creating meaningful products by practicing what they learn. Sari et al. (2017) stated that project-based learning allows students to think creatively in finding materials from the surrounding environment and also appropriate procedures to produce a product/project. Group work stimulates students' collaboration and thinking skills with more enjoyable learning (Zatya et al., 2022). The learning innovation that can be done with PjBL is through the integration of STEM Approach. Each STEM step integrated in PjBL helps students develop flexibility of thinking by linking real life and knowledge gained at school, and providing various possible answers. Creative thinking activities and abilities are higher when students conduct discussions or experiments to produce a product, compared to only receiving information or concepts from the teacher (Sumarni & Kadarwati, 2020).

The inquiry learning model is related to the theory of constructivism. Inquiry activities can improve students' creative thinking skills (Dewi & Mashami, 2019; Lestari et al., 2020; Perdana et al., 2022a; Perdana et al., 2022b). This is because inquiry actively encourages students to search, discover, and develop their own knowledge (Dewi & Mashami, 2019). Based on 4 articles that examine Inquiry learning models, there are 2 articles about the Inquiry Social Complexity (ISC). ISC enhances students' creative thinking skills through higher-order learning aspects and specially designed learning syntax. Syntax activities, such as observation, reconstruction, socialization, verification, and communication, focus on training specific aspects of creative thinking skills (Perdana et al., 2022a; Perdana et al., 2022b). Perdana et al. (2022a) revealed that student interaction in collaborative learning, stimulation of curiosity, and the use of evaluations and tests contribute to the development of creative thinking skills. Through the ISC model, students can be more actively involved in the learning process, improve logic, and develop creative abilities that are useful in school and in the world of work. In addition, 1 of the 4 articles discusses integrating the Chemoenterpreneurship (CEP) approach with the inquiry model. This learning invites students to learn the process of processing natural materials into products based on the chemical concepts learned, which will contribute to fostering student creativity. Based on the results of Dewi & Mashami's (2019) research, the application of an inquiry model oriented to the CEP approach can improve students' creative thinking skills which are also followed by an increase in their learning outcomes. The inquiry model can also be integrated with a flipped classroom approach to develop students' creative thinking. Lestari et al (2020) revealed from the results of their research that students who use learning with the guided inquiry model-flipped classroom approach are more active because of their readiness to understand the material to be discussed in class. Remembering and understanding are low-level thinking that is practiced outside the classroom. While in class students learn with a focus on higher-level thinking such as applying, analyzing, evaluating, and creating. This makes students' creative and emergent thinking skills better.

Based on the results of the literature review, there is 1 article that discusses the Contextual Teaching and Learning Model (CTL) in improving creative thinking skills. The use of CTL models can make students develop detailed and interesting ideas from a situation. In this case students are directly involved in problem solving so that students have the opportunity to generate new ideas widely and diversely (Sihaloho et al., 2022). Another learning model that is proven to improve students' creative thinking is the guided discovery learning (GDL) model. GDL models have a syntax that allows students to think creatively which is part of higher order thinking. In this learning, students are placed in situations where they can use scientific concepts in the form of technology to provide benefits to humans and are asked to think about the consequences that may occur. this model makes learning more flexible and stimulates student innovation and creativity (Yerimadesi et al., 2022).

Overall, the results of the article review on creative thinking skills in chemistry learning according to the chosen research focus are summarized in Table 6.

Table 6. The Summary of Creative Thinking Skills in Chemistry Learning with Several Parameters

The number of students	Strategy			Learning outcomes	Test score result	Authors
	Method	Approach	Model			
125 chemistry education student	Discussion	Scientific approach	Problem Based Learning	The average value of student learning outcomes with the PBL model (48.11) is higher than students with conventional methods (36.76)	Based on the results of Anova obtained sig value. 0.000 (0.000 < 0.05) which shows that there is a significant difference in the average value of creativity of students taught chemistry using problem-based learning.	Adah & Akomaye (2022)

The number of students	Strategy			Learning outcomes	Test score result	Authors
	Method	Approach	Model			
92 chemistry education students	-	-	-	The learning outcomes of students are influenced by their creative thinking skills. This study found that the level of students' creative thinking tends to be moderate, with low levels of flexibility and fluency.	The level of creative thinking of students is in the medium category with a percentage score of 35.43	Apriwanda & Hanri (2022)
20 chemistry education students	Discussion	Chemo-Entrepreneurship (CEP)	Inquiry Based Learning	The average student learning outcomes are 72,25	N-gain score is 0,49 (medium category)	Dewi & Mashami (2019)
188 chemistry education students	-	-	-	This study shows that students with low creative thinking skills in biochemistry tend to have bad learning outcomes.	Students' creative thinking skills on biochemistry material are less than 50 percent in the good category, with details of the sensitivity indicator 44.7%; fluency 41.5%; flexibility 40.4%; originality 43.1% and elaboration 39.4%.	Ernawati et al (2019a)
46 chemistry education students	Scaffolding	Scientific Approach	Problem Based Learning	-	All items are declared valid, with scores above the table rxy value (0.34). The reliability of the instrument is in the high category with a r11 value of 0.75.	Ernawati et al (2019b)
113 chemistry education students	Scaffolding with discussion method	Scientific approach	Problem Based Learning	The average student learning outcomes are 48.68	Significance value of Anova test is 0.000 (sig < 0.05) which indicates a significant difference in the average creative thinking results terms of psychomotor aspects	Ernawati el al (2022)
26 senior high school students	Question-Answer, Discussion	STEM Approach	Project Based Learning	The average student learning outcomes are 80	The n-gain score is 0,73 (high category)	Hasibuan et al (2022)
70 senior high school students	Discussion	Flipped Classroom Approach	Guided Inquiry	The average student learning outcomes are 82.866	The significance value of two-way anova test is 0.019 (sig < 0.05), which means that there is an effect of the flipped classroom approach on the guided inquiry model on students' creative thinking skills.	Lestari et al (2020)
74 chemistry education students	Discussion and presentation	Green Chemistry approach	Problem Based Learning	The average student learning outcomes are 82.42	The n-gain score is 0.73 (high category)	Nuswowati et al (2017)
62 senior high school students	Discussion	Scientific approach	Inquiry Social Complexity (ISC)	The average student learning outcomes are 80.83.	The n-gain score is 0.75 (high category)	Perdana et al (2020a)
180 senior high school students	Demonstration, discussion, Presentation	Scientific approach	Inquiry Social Complexity (ISC)	-	The results of students' creative thinking skills have increased, in the fluency aspect from	Perdana et al (2020b)

The number of students	Strategy			Learning outcomes	Test score result	Authors
	Method	Approach	Model			
					45.83% to 52.80%, the flexibility aspect from 37.28% to 55.20%, the originality aspect from 35.01% to 54.86%, the elaboration aspect from 41.14% to 47.50%	
40 chemistry education students	Blended learning method	Environment-based learning approach	Project Based Learning	The average student learning outcomes are 37.55	The n-gain score obtained is 0.32 (medium category)	Sari et al (2017)
61 senior high school students	Discussion	Contextual Approach	Contextual Learning Model	The posttest results of the CTL model class were 78.84%, which reached the minimum completion criteria (KKM) and indicated a high level of student creative thinking.	The t test results obtained the value of t_{count} = 2.240 and t_{table} = 2.042 (t_{count} > t_{table}). meaning that the application of the CTL model has a positive effect on students' creative thinking skills.	Sihaloho et al (2022)
230 senior high school students	Discussion, question and answer, presentation	Ethno-STEM approach	Project Based Learning	The average student learning outcomes are 38.3	The n-gain score obtained is 0.33 (medium category)	Sumarni & Kadarwati (2020)
72 chemistry education students	Discussion and Question-Answer	STEM-Local Culture Approach	Problem Based Learning	The average student learning outcomes are 73.32	The n-gain score obtained is 0.54 (medium category)	Sumarni et al (2022)
74 chemistry education students	Demonstration, Discussion, Presentation	SETS Approach	Guided Discovery Learning	The average student learning outcomes are 81.11	The t_{count} value obtained is 1.90. t_{count} > t_{table} (1.90 > 1.66). This shows that the application of the Guided Discovery Learning Model with the SETS approach assisted by the E-module has a significant effect on the creative thinking skills.	Yerimadesi et al (2022)
52 senior high school students	Discussion and Presentation	STEM Approach	Project Based Learning	The average student learning outcomes are 83.00	The n-gain score obtained is 0.8 which is in the high category	Zatya et al (2022)

Based on Table 6, it was found that the level of creative thinking skills was still in the low to medium category, with the percentage of their creative thinking skills less than 50% (Apriwanda & Hanri, 2022; Ernawati et al., 2019a; Sari et al., 2017). The low level of creative thinking skills is due to the fact that students are not used to being trained to develop their creative thinking (Hasibuan et al., 2022; Lestari et al., 2020; Sihaloho et al., 2022; Yerimadesi et al., 2022). As revealed by Sumarni et al. (2022) that succeeding in developing creativity is highly dependent on the learning system implemented. In learning chemistry, students are more likely to learn by memorizing and only listening to the teacher's explanation (Sihaloho et al., 2022). This way of memorizing has a negative impact on students' creative thinking skills in processing and constructing information. Students as learners should be able to build their own understanding from experieince and make meaning from what they learn.

The highest student learning outcome found by researcher from the results of the literature review is 83.00, these gains indicate that improving creative thinking skills is most effectively done by using the Project Based Learning (PjBL) model with a STEM approach. Although research related to creative thinking skills uses more problem-based learning (PBL) models (33.3%), but the student learning outcomes show that the PjBL model provides the highest learning outcomes among other learning models.

The application of PjBL with STEM approach is effective in improving creative thinking skills because this learning model involves students actively in

designing products using STEM which provides opportunities to increase creativity. In addition, this learning model requires students to be accustomed to connecting material with daily life, developing ideas and adding the best solution to solve problems when completing specific projects (Zatya et al., 2022).

Creative thinking skills can be measured using several indicators, namely fluency, flexibility, originality, and elaboration (Apriwanda & Hanri, 2022; Ernawati et al., 2019a; Hasibuat et al., 2022; Lestari et al., 2020; Sumarni & Kadarwati, 2020; Sumarni et al., 2022; Yerimadesi et al., 2022). The increase in creative thinking skills is also followed by an increase in learning outcomes. Students with good creative thinking skills tend to have better learning outcomes. This is because creativity can help students solve problems and generate new ideas in learning (Ernawati et al., 2019a; Nuswowati et al., 2017).

Conclusion

Creative thinking skills are one of the competencies needed by every individual. Many studies have been conducted to investigate creative thinking skills in chemistry learning. Along with the many studies that have been conducted, various learning models are used to improve creative thinking skills, with a focus on prospective chemistry teacher students who have a crucial role in developing students' creative thinking skills. The results of the literature review found that the Project Based Learning (PjBL) model with the STEM approach is the most effective learning in improving creative thinking skills, with a learning outcome value of 83.00. The improvement of creative thinking skills is in line with the improvement of student learning outcomes. Thus, this research underlines the importance of developing creative and innovative learning in shaping students' creative thinking skills in chemistry, with special attention to the preparation of prospective teachers as agents of change in the world of education.

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The authors declare no conflict of interest

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